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G. L. RUSSELL, TRAFFIC ENGINEER

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GUARDRAIL
AS IT IS NOW

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Prepared by:

Edward J. Tye
Asst. Traffic Engineer

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The present (1969) design for metal beam guardrail with end anchors contains many subtle details. The basis for some of these details may not be readily apparent and in many instances has not been documented. This is an attempt to provide that documentation.

The "W" rail element is mounted on an 8" x 8" x 5'-4" rough Douglas Fir post. The post is imbedded 3'-0" in the ground and the top of the rail is 27" above the ground. Impact tests and measurement of recent automobile bumper height and configuration make the 27" height desirable to forestall a vehicle climbing over the rail. A higher rail requires some sort of rubbing rail to prevent snagging on the posts. Post spacing has been reduced to 6'3" to provide added resistance to lay back on impact which would allow a vehicle to go over the rail. The reduced post spacing also lessens the tendency of the rail to form a pocket during impact. This has been made necessary by faster and heavier vehicles.

The "W" rail is spaced out from the 8" x 8" post with an 8" x 8" x 14" S4S Douglas Fir block. The block gets the contact area out from the post where there is little possibility of the vehicle snagging on the post. Also the blocking allows the rail to rise slightly on initial impact, which reduces vehicular roll potential. Surfaced four-side blocks are used because when double barrier is used, two rough blocks with plus or minus tolerances would result in back-to-back rail spacing that would vary considerably and be obvious to the average motorists. This appearance factor was considered objectionable and led to the required use of surfaced blocks for barrier rail.

The toe nails on the blocks were added when it was observed that blocks on recent projects had rotated, most noticeably where reflector units were attached to the blocks. At first it was thought that the mounting bolts had not been properly tightened during installation. Investigation determined that blocks were being installed properly but subsequent shrinkage of the timber introduced enough slack to permit rotation of the block.

The batter at the top of the post was eliminated when operational investigations indicated that a large number of mounting bolts were splitting the posts and pulling out through the top of the posts on impact. It was felt that the amount of material gained by eliminating the batter would be structurally beneficial. Also, prior bases for the batter were outweighed; namely, aesthetics and drainage of water from untreated post tops.

The rail, block, and post are fastened together with a 5/8" carriage bolt with a hex nut and cut washer on the back side of the post and a flat plate washer under the head of the carriage bolt. Previous standards required the carriage bolt without any washer under the head. Cut washers were added locally when it became apparent that the carriage bolt heads were slipping through the slotted mounting holes in the guardrail. Also maintenance forces found it necessary to use cut washers when they used hex head machine bolts in repairing damaged guardrail. Subsequent investigation of accident sites revealed that both the carriage bolts and machine bolts with cut washers were pulling through the slotted mounting hole in the guardrail when involved in an accident. In some cases they were pulling through the rail at splices. This information led to the adoption of the metal plate washer. The first washer had an 11/16" x 1" slotted hole. This was mainly on the basis that these were the dimensions of the holes that other states were using. Later investigation showed that the slotted hole was used in consideration of a mounting bolt with special shoulders. The slot was not necessary for lateral movement. Thus, the 1969 Standards call for 11/16" square hole in the flat plate washer. Considering that either hole is punched there should be no cost differential in fabrication. The square hole will keep the carriage bolt from rotating during installation. It will also allow a machine bolt to be used with maximum bearing for the bolt head. It is interesting to note that some maintenance forces were using home-made flat plate washers for some time prior to their consideration for Statewide use. These were in the snow country where static loading under road closures is quite severe.

Nothing has changed with respect to rail splices. However, the nuts and bolts used are unique enough to require comment. The bolts have an oval head much like a carriage bolt. Instead of square shoulders they have two pointed shoulders that serve the same purpose. These shoulders are deep enough to extend past the double thickness of rail metal at a splice and a normal nut would bind on the shoulders before bearing on the rail. Hence, nuts with a recess are specified. The nuts are installed with the recess toward the rail and the recess allows the nut to be tightened against the rail without a hangup. There have been instances of nuts being installed with the recess away from the rail. The use of double recessed nuts eliminates this problem.

Guardrail anchorage was developed when it became apparent that short sections of guardrail (less than 100 feet) were not providing satisfactory protection for today's heavier and faster vehicles. In some instances entire unanchored guardrail installations were carried away at impact, allowing vehicles to strike the protected objects. Subsequent full scale impact tests indicated that about 60 feet of guardrail were required to be equivalent to an anchor. Based on this, the ends of all guardrail installations should be anchored, even long runs of embankment guardrail.

The cable anchor is a hybrid design based on other anchor designs and California's experience. Originally the anchor block eye was just outside the concrete cylinder and buried. Potential corrosion problems caused the rod to be extended to bring the eye above the ground. The Crosby cable clips used to secure the cable to the anchor rod eye must be installed correctly. The "U" bolts go on the short end of the cable and the saddle on the working end.

The Construction Safety Orders of the Department of Industrial Relations indicate that three clips develop 80 percent of the breaking strength of the cable. The original design used in impact tests used five clips. This design was transferred into the standards. Later discussions indicated that four clips might be satisfactory; however, subsequent operational reports denoted instances where the cable was stripped through all five clips. Hence, five clips will be retained. There is concern in some quarters that the nuts on the clips are not being drawn up tight enough. So tensioning requirements similar to those under Cable Median Barrier are being considered for inclusion in the Standard Specifications.

There is also some concern as to "how tight" the cable should be. The best described requirement would be taut, not draped. There is nothing to be gained in having the cable tone tight or twangy, simply because by the next day the ground would have displaced enough to relax the cable.

The present 1/4" anchor plate has proven satisfactory and appears to be reusable by maintenance forces after most impacts. Care must be taken, however, to see that they are properly inspected and meet specifications. In one instance, a "bootleg" anchor plate failed due to poor welds.

The concrete anchor presently shown in the 1969 Standard Plans is essentially that used in original designs. A forthcoming change in the design brought about by a Value Engineering team should reduce the cost of this item. The change essentially substitutes reinforcing steel for the 8 WF 17 beam.

When the leading end of a guardrail installation is tucked and anchored into a slope it can become impractical to use the standard cable anchor. Large amounts of costly excavation may be necessary to place the concrete anchor block beyond the end of the rail in steeper cut slopes. In these cases, alternative anchors are desirable. Two acceptable end post anchors are: (1) using a 12" wide flange steel post set in concrete; or (2) the short rail post of Standard Plan A79-D set on the concrete foundation in Detail "B" of the same Standard Plan. Either alternative is acceptable as long as the steel post and the end of the rail are buried in the slope.

Another and more satisfactory method of anchoring guardrail in cut slopes involves no special or unique hardware. All that is necessary is to move the anchor back from the end one or more post intervals (multiples of 6'3"). This also moves the concrete anchor block back between the posts where less excavation is required.

The 1969 edition of the Standard Plans shows both types of terminal sections. Previously only the circular terminal section was shown while in general practice the fishtail section was most used.

With the advent of anchored guardrail, the blocking at the cable anchor end was modified to have no block on the end post and a 4" block on the post next to the end. All other posts normally require a full 8" block. This is done to provide a stronger anchorage of the beam at the ends of the guardrail. It also permits some additional set back of the beam end from the traveled way.

The metal box spacer used at the structure end of an approach guardrail installation was introduced after the first impact test. The first impact test of structure approach guardrail used a timber block and a parabolic flare. Upon impact the flare reversed itself, the timber block split and block mounting bolts folded over. All of this allowed the vehicle to be pocketed in the rail and led into the structure parapet with devastating results. The taper of the metal box spacer allows the guardrail to approach the structure on a straight line and eliminates any slack which could allow pocketing.

Another item that grew out of this first approach guardrail impact test was the apparent need for gradual stiffening of guardrail as it approached the structure.

The method chosen involved cutting post spacing in half and using posts with greater cross section in the immediate vicinity of the structure. Based on operational performance this method appears to be most satisfactory.

There are other facets to guardrail installations based on present designs in the Standard Plans. Most of these are self-explanatory or have been documented either in circular letters, traffic bulletins, or Materials and Research Department reports. The flares and other installation details shown in the Standard Plans are intended to be both general and typical. It is not practical to try to anticipate each and every possible situation and provide a standard covering it. Hence, the designers have been allowed some opportunity to exercise their mental processes and abilities.